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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B29C 65/48, F16L 15/00, 47/02 | A1

(11) International Publication Number: WO 91/18733

(43) International Publication Date: 12 December 1991 (12.12.91)

(21) International Application Number: PCT/US91/03597

(22) International Filing Date: 22 May 1991 (22.05.91)

(30) Priority data:
531,984 1 June 1990 (01.06.90) US

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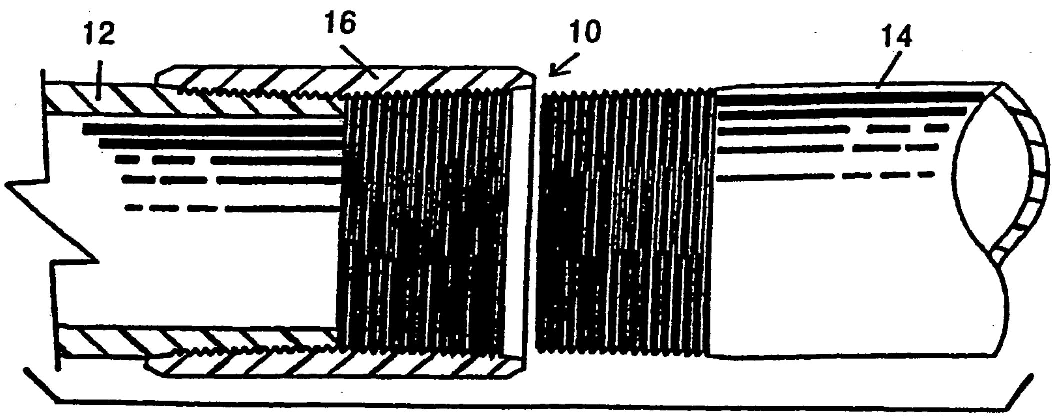
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), NL (European patent), NO, RO, SE (European patent).

Published
With international search report.

(54) Title: METHOD OF JOINING THREADED NON-FERROUS PIPE SECTIONS



(57) Abstract

A sealing system (10) is provided for composite fabricated pipe sections (12, 14, 16) having threaded connections on the end thereof with said connections being of composite material for use in assembling pipe sections in a piping system. A two component thermoset polysulfide elastomer (20) in the material's flowable unpolymerized state is coated upon the entire area of the connection threads. The pipe sections (12, 14, 16) are then assembled in a normal fashion with the elastomer (20) prepared connectors to produce the sealing system (10). With time, the polysulfide material (20) crosslinks and forms an uncompressed elastomeric seal along the entire helix length of the threaded connection producing pipe sections (12, 14, 16) with threaded connections that possess greater hydrostatic pressure capacities. Without the requirement of compressing the elastomer to form the hydrostatic seal, the sealing system (10) produces effective seals with a wide range of assemblage torques for the interconnection of the pipe sections; ranging from hand tight to power tight engagements of the connections. The sealing system (10) allows the connection of pipe sections (12, 14, 16) with or without the aid of tools. Without a determined interconnection engagement length required to form the seal in the connection, pipe sections may be placed into any rotational positioning to facilitate the assemblage of the piping system. The sealing system also provides the means to seal the connections of pipe sections with adversely damaged threads.

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METHOD OF JOINING THREADED NON-FERROUS PIPE SECTIONS

BACKGROUND OF THE INVENTION

The invention relates to methods of joining non-ferrous pipe(or tubing) of plastic or fiberglass, for example. More particularly, this invention relates to an improved non-ferrous pipe which allows for relatively high pressure use of the pipe, while at the same time permitting repeated assembling and disassembling of the pipe coupling connections. According to an even further aspect, this invention relates to an improved pipe having substantial latitude as to the required makeup torque for effective sealing of the pipe.

Pipe sections used for high pressure (greater than 1,000 PSI) oil field applications have typically been interconnected by threaded connections to form piping systems. Steel pipe sections with steel threaded connections have easily produce reliable seals and connections. An advantage steel has over composite pipe sections is composite pipe sections with threaded connections are plagued by interconnection failures such as thread leaks. The major disadvantage of steel sections/connections are their lack of resistance to corrosion.

It has been common to use pipe sections having threaded couplings on the end thereof for interconnecting pipe sections formed from resin impregnated filament wound materials to form pipe sections in oil field pipe applications, such as in U.S. McLarty Patent 3,572,392, issued Mar. 23, 1971; U.S. Carter, et al. Patent 3,784,239, issued Jan. 8, 1974; and U.S. Meher Patent 3,540,757, issued Nov. 17, 1970.

The use of non-corrosive pipe sections has been hindered by problems present in effectively joining the sections of pipe together. One method of assembling the same is to lay the sections of pipe at the place of intended use and then connect the sections by bonding with adhesive. This method of assembly poses problems such as the necessity of forming a complete bond between the sections to provide an effective seal and the necessity of waiting while one bond is taking place before the next section can be positioned and connected. In addition, this method is limited to low pressure applications (lower than 500 PSI).

The major source for failures in composite piping systems which are threadedly interconnected are leaks between the pin and female threads. These connections possess the shortest service life of all components in the composite piping system. Thus, the elimination of thread leak type failures would extend the service life of the system to the mechanical limits of the composite material.

Two factors of composite materials, 1) poor machineability, and 2) brittle behavior (lack of plastic deformation) give rise to the manufacturing of ineffective sealing threads. Composite materials are more difficult to machine than their steel

counterparts for which NPT, 8RD and other sealing threads were originally designed. Sealing threads require close tolerances which are difficult to hold when machining composites. Also, difficulties arise with surface finishes of the composite threads which are magnitudes higher than that of steel. When assembled the tolerance and surface roughness prevent close fits, thus allowing leakage to occur between threads. Further, the brittle nature of composite thread does not allow plastic material deformations to occur to further take up geometry mismatches, such as that seen in ductile steel threads capable of plastic deformation.

Thus in the sealing of composite threaded connections some method must be employed to take up thread geometry mismatches. Particulate impregnated greases (thread dopes) have been used. The particulates dam potential leak paths between the threads of the connection. Problems encountered in composite connections with thread dopes are: 1) washout of the dope from the connection, 2) mismatch of particulate sizes to leak path size, and 3) extreme dependence on proper connection make-up torque. Assembly torque affects leak path size, the leak path size decreasing with increasing torque.

Teflon sealing tape in conjunction with thread dope has been used to increase the sealing capacity of composite threaded connections. This system can provide satisfactory seals if proper installation occurs. This system is still prone to thread leak failures whenever the tape is applied incorrectly or the connection is made with low assembly torque. Sealing tapes are disliked in field applications due to the fact that tapes are not used/required in steel connections.

The best effective method to provide hydrostatic seals at the time of this invention was the use of teflon sealing tape and a teflon impregnated thread compound dope. This method, however, was difficult to use in the field and provided unreliable seals if connection assembly was not properly executed. This method consisted of first applying the teflon tape (approximately 1" wide x 3-4 mils thicks) to the male thread of the connection. The tape had to be applied in a clockwise direction (looking at the male end) starting at the largest thread diameter and progressing towards the toe of the male thread length overlapping each circumferential pass by 1/2 of the tape width for a total of four passes of tape over the thread length. Application of the sealing tape in a counterclockwise direction would ball the tape between the male and female threads producing a guaranteed sealing failure. Overlapping or under lapping of the tape could also produce sealing failures. For a two inch 8RD thread, approximately 72" of tape is used. Accordingly, the applicator must exhibit some manual dexterity and coordination. Next, thread compound is applied to both the teflon wrapped male threads and the female threads. Finally, the connection is made by screwing the male end into the female end by applying torque to the components. High torques (generated with hand tools) of 200 to 300 ft.lbs

are required to make the connection seal. Under-torqued connections result in sealing failures while over-torqued connections generate through wall fractures in thinner walled products. To date, no effective economical method is available to measure the assembly torque in the field. Estimation of torque by the "turns" method is ineffective due to varying thicknesses of teflon tape on the pins. The determination of the correct assembly torque is the intuition of the field hands who assemble the connection.

Elastomeric seals (such as in the form of O-rings) have been used to eliminate the problem of proper sealing of the connection threads. See, for example, the U.S. Carter, et al. Patent 3,784,239. Seals of this type require the compression of the elastomer to form the seal. Over time, the elastomer may experience compression set and lose sealing capacity. Additional problems are: 1) extra machining of the connectors to accept the seal, 2) pinching, tearing or roll out of the seal during assembly of the connection, and 3) elastomeric seals usually only provide a contact sealing area of hundredths of an $inch^2$ (example: #227 O-ring with .005" compression set exhibits 0.387 in^2 of contact area.)

The present invention provides a coupling in which sealing is substantially independent of the degree of tightening between the respective coupling elements. Further, the coupling is not subject to leakage of fluid through the female coupling element as in the prior couplings.

SUMMARY OF THE INVENTION

The invention provides a method of joining non-ferrous pipe comprising a male threaded section, and a female threaded section, the male and female pipe sections being intended to be repeatedly joined and disconnected, the method comprising the steps of: applying a cold curable elastomeric compound with a durameter range of 30 to 60 Shore A to at least one of the male threaded section and the female threaded section, and then threading the male section into the female section before the cold curable compound crosslinks so that an uncompressed elastomeric seal forms between the male and female pipe sections.

One of the principal features of the invention is the provision of an improved resin impregnated filament pipe section having male and female threaded couplings formed on the ends thereof which can be interconnected utilizing a wide range of assemblage torques while at the same time effecting a high pressure seal. The seal also has high chemical resistance to chemicals found in oil field environments, and is similar in application to the use of pipe dope on steel pipe. Thus, this sealing process is familiar to those who presently use steel pipe in the oil fields.

Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings.

Before one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and if being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of piping which embodies various of the features of the invention and which comprises two male threaded sections, the right most of which is shown in plan view, and the left most of which is shown in cross section, and a female threaded section shown in cross section.

FIG. 2 is an enlarged cross sectional view of the piping illustrated in Fig. 1 and depicting the mating threads of one of the male sections and the female section, showing a sealant between the threads.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, Fig. 1 illustrates a pipe 10. The pipe 10 is provided with two male threaded sections 12 and 14 joined together by a central threaded tubing portion or female section 16. In the preferred embodiment, the pipe 10 is constructed in accordance with a conventional method from resin impregnated fiber material. In other applications, other non-ferrous materials may be used.

The pipe 10 can be used in numerous environments, such as in an oil field pipe system. When the pipe 10 is used as an oil field pipe, the sections are constructed with an end to end length of approximately thirty feet and are made in 2 inch, 3 inch and 4 inch and other standard pipe sizes. In an oil field pipe system a number of the pipes 10 are connected together in series by use of the male and female sections.

When the pipe system is assembled in the field, the following method of joining the non-ferrous pipe 10 is used in the preferred embodiment of the invention. A cold curable polysulfide elastomeric adhesive compound 20 with a low shear strength and with a durameter range of 30 to 60 Shore A is applied to the male threaded section 12. In the case of a 2 3/8 inch joint, about 15 grams of compound is used. The male section 12 is then turned into the female section 16 with a strap wrench to where there is between 50 and 100 ft-lbs. of torque on the joint. This is done before the cold curable

compound sets. As a result, an uncompressed elastomeric seal forms between the male and female pipe sections along the entire helix length of the threads (102" in a 2 3/8" BRO thread.). The same procedure is then followed with the second male section 14. In this application, a polysulfide compound is one which contains polysulfide (a polythioether polymer). Also, in this application, an adhesive is one which has a peel strength of between 20 and 40 lbs. on a 2 3/4 inch wide sample of aluminum, and a compound with a low shear strength is one with a shear strength between 100 and 300 psi.

In other embodiments, other cold curable compounds can be used. The polysulfide elastomer compound has the best chemical resistive properties known for an oil field application, however, as well as the ability to remain flowable for a reasonable time in the field (a pot life of about 2 hours before starting crosslinking), while still fully curing in an appropriate time (72 hours). The polysulfide elastomer also has the following desirable characteristics: an elongation parameter of 200% allowing differential radial deflections to occur between the coupling/pin thread connection due to temperature changes, compliance mismatches, pressure and axial loads while effectively maintaining a high pressure seal; a tensile strength of 200-300 psi preventing extrusion and washout between the connection threads; and a viscosity of 13,500 to 1,100,000 centipoise.

Development History of the use of Polysulfide Elastomeric as a Hydrostatic Sealing Agent in Composite Pipe with Threaded End Connections

In the middle of the month of March 1989, a project was started to develop a user friendly sealing system for composite pipe with threaded end connections. The objective was to discover/develop a stand alone (used without Teflon tape) thread compound which may be applied to fiberglass 8RD threads that provides the proper lubrication and sealing properties that are equivalent to the standard joint prep of paste Teflon tape and fiberglass thread lube which has an average liquid failure pressure of 8378 psig, standard deviation of failure pressure of 319 psig and 95% LCL failure pressure at 7753 psig. The benchmark for disassemblage torque was in the 270-320 ft.lbf. range.

Experimental work began in late March 1989. The hydrostatic performance of a commercial fiberglass thread compound labeled LS-245 was evaluated. The LS-245 compound fell short of the pressure criteria and exhibited a large scatter in performance. At this time forward, applicant worked with Galaxie International on modifying the LS-245 compound for higher hydrostatic performance and less variation in performance. The compound was improved over time but it never prevented thread leak failures and was highly dependent on assembly torque to produce seals.

Experimental work was also conducted on three commercial epoxy adhesives and two anaerobic pipe sealants formulated for metal threaded connections.

Two epoxy sealants, Tracon Tri-Bond and Hysol LI-8820 performed poorly producing thread leaks type failures at pressures 55% to 65% of that of the standard sealing method. The third epoxy sealant, Felpoxy GP, produced ultimate bursts near that of typical sealing method for that product class without thread leaking but failed by a less common type of failure, that being a coupling weep (fluid penetrates composite material to exterior of vessel). The third epoxy was evaluated for disassembly capability; no disassembly was possible. The pipe sealant Seal-Lube #1001 produced variable results in hydrostatic performance. The second Seal-Lube product #LTF-4444 performed poorer than the #1001 compound.

Flexibilized epoxy adhesives were also evaluated for sealing capabilities in composite threaded connections. Base adhesive S1A was flexibilized with amine terminated butadiene (ATBN). Hydrostatic performances using the flexibilized epoxy adhesive as a sealant never met the performance of the standard tape/dope sealing method. It was discovered that the use of epoxy adhesives as a sealant initiated fractures in the connection which produced through wall failures in couplings. In addition, none of the flexibilized epoxy adhesives developed possessed any disassembly capabilities. The most important discovery with this experimental work with the flexibilized expoxy versions was that as the flexibility of the sealant material increased, so would the hydrostatic performance of the composite connection. Unfortunately, even the ATBN sealant version flexibility decreased with temperature becoming severely brittle at below 20 degrees F.

Seven thread seal compounds from three different manufacturers were evaluated in the lab for sealing capacity in 2 3/8" 8RD fiberglass threads. Test joints were constructed from a TBS 2510 cut thread coupling and a TBS 2010 paste thread pin. Compounds were applied to the joints per manufacturer's recommendation. Joints were made up at 225 +/- 25 ft.lbf. and then evaluated for short term burst properties at room temperature. Only one product manufactured by Galaxie International, LS-245 fiberglass thread compound approaches the thread sealing capacity of the standard prep within 97.6% on average burst, but has a standard deviation 2.36 times that of the standard prep. This compound also had favorable disassembly properties.

The seven candidates evaluated are described below:

Candidate #1: "Jomar Seal Green Stuff" distributed by Jomar International, (313-3985020). Thread sealant designed for plastic threads. Applied sparingly to a cleaned joint. Slow drying soft set material. No lead content.

Candidate #2: "Jomar Seal Tef Seal'- distributed by Jomar International. Thread sealant designed for fiberglass piping. Applied sparingly to a cleaned joint. Slow drying soft set material. Contains Dupont TFE fluorocarbon resin. No lead content.

Candidate #3: "Jomar Seal Heavy Weight" distributed by Jomar International. Thread sealant designed for metal to fiberglass joints. Non-hardening material. Applied to clean male threads only. Will evaluate in glass-glass joints.

Candidate #4: "Jomar Seal Water, Oil and Gas Plus" distributed by Jomar International. Thread sealant. Compatible with epoxy threads. Applied to a clean joint by filling the roots of the male-threads flush to the thread crest with compound. 30-45 minute drying time, firm set material with some flexibility. Cured by solvent evaporation.

Candidate #5: "LS-256B" distributed and manufactured by Galaxie International, (713-225-4179). Thread sealant designed for fiberglass pipe. Applied to clean joint without the use of Teflon tape. Contains paste Teflon particles for sealing capabilities and sized sinistered (hard) Teflon particles for lubrication. Non hardening. No lead.

Candidate #6: "LS-245" distributed by Galaxie International. Same as #5 candidate except percent weight of Teflon changed along with different particle sizes. No lead.

Candidate #7: "Seal Lube #1001" distributed by Thread Masters, Inc. (713-458-7376). Thread sealant designed for 8RD and buttress metal threads. Paste cures to a firm set as polymer cross links in the presence of a catalyst called Primer-N manufactured by Lock-Tite. In this test, concentrated Primer-N was applied to both the bell and pin. In the concentrate form, Primer-N is very corrosive presenting material handling problems in the field.

Table 1 - Physical Properties

Attribute	#1	#2	#3	#4	#5	#6	#7
Color	Green	White	White	Rust	Gray	Dk.Gra y	Gray
Workable To	-50 F	-50 F	0 F	-50 F	0 F	0 F	-65 F
Max Sys Temp	400 F	500 F	600 F	500 F	450 F	450 F	300 F
Min Sys Temp	-50 F	-100 F	-200 F	-50 F	None	None	None
Max Sys Pres (Gases)	3000 psi	2000 psi	3000 psi	2500 psi	NS	NS	8000 psi*
Max Sys Pres (Liquids)	6000 psi	8000 psi	10000 psi	10000 psi	NS	NS	16000 psi*
Flash Point	43 F	43 F	NS	65.2 F	450 F	450 F	375 F
Texture	Paste	Paste	Paste	Liquid	Buttery	Tar	Paste
Set	Soft	Soft	None	Firm	None	None	Soft

NS = Not Stated

*Metal Threads

**As reported by manufacture

Three joints of each thread sealant candidate was prepared to evaluate for quick burst ultimate, breakout torque and thread condition after breakout. Candidates evaluated in a TBS 2010 joint consisting or a TBS 2510 coupling with 8RD cut threads and a 2010 pin having paste threads. Sealants were applied to the joints as specified by the manufacturers. Make-up torques were 225 +/- 25 ft. lbf. Joints were allowed to set for 24 hours at room temperature before testing. All testing was conducted at room temperature using tap water.

Results

Table 3 - Ultimate Burst Pressures and Breakout Torques of Sealant Candidates

Candidate Sealant	Trial	Burst Pressure	Failure Type	Breakout Torque
1	1	4482	Thread Leak	282
	2	6696	Thread Leak	308
	3	5642	Thread Leak	324
2	1	6652	Thread Leak	364
	2	6492	Thread Leak	374
	3	5564	Thread Leak	370
3	1	7404	Thread Leak	310
	2	7356	Thread Leak	296
	3	6550	Thread Leak	284
4	1	7114	Thread Leak	333
	2	4982	Thread Leak	320
	3	5348	Thread Leak	340
5	1	5850	Thread Leak	253
	2	4480	Thread Leak	260
	3	5348	Thread Leak	224
6	1	8270	Thread Leak	265
	2	7382	Thread Leak	283
	3	8880	Thread Leak	220
7	1	5784	Thread Leak	297
	2	5100	Thread Leak	310
	3	5450	Thread Leak	302

Statistics

Table 4 - Average, SD and 95% LCL Burst Pressures of Sealant Candidates

Candidate Sealant	Average Burst (psi)	SD Burst (psi)	95% LCL* Burst (psi)
#1	5773.3	864 5	4078.9
#2	6236.0	587.4	5084.6
#3	7103.3	479.8	6162.9
#4	5814.7	1140.0	3557.4
#5	5226.0	693.1	3853.6
#6	8177.3	753.3	6700.9
#7	5444.7	342.0	4757.6
Standard	8378.0	319.0	7753.0

95% LCL = Average - 1.96 SD

Observations

All candidates failed by thread leaks. Candidates #1, #2, and #3 washed away during leaks. For the remaining compounds, no visible washout was observed. All candidates had good

disassembly torques and did not gall the threads. In general, all candidates fell short of a desired sealing capacity.

The compound LS-245 candidate #6 was the only compound that performed close to the objective burst pressures. LS-245 was within 97.6% in average short term burst pressure when compared to the standard prep. However, the LS-245 has a standard deviation in burst pressure 2.36 times that of the standard prep resulting in a 95% LCL burst pressure of only 86.4% in comparison. The sealing capacity of the LS-245 was dependent on assembly torque.

With the discovered knowledge that no-setting to soft-setting sealant materials were not resistant to thread leak failures and that hard setting epoxy adhesives generally prevented thread leak failures but initiated and promoted through wall fractures in connections at below the required pressure criteria, a sealing material would be required that had a medium set such as an elastomer.

Criteria for this sealant elastomer would be: a set of 30-60 durameter shore A, a cold curable material (an elastometer which could cure at ambient temperatures), a material which would be in a flowable state at normal ambients, and possess some adhesion capacity to prevent thread leaks and wash out but low enough shear strength to allow disassembly.

After two weeks of searching through a material handbook, the polysulfide elastomeric used as a sealant in the aircraft industry was discovered and presented features that would meet the above criteria. The first sample was evaluated in early September of 1989. The polysulfide elastomer produced sealing capacities to 10,000 psi hydrostatic without failure. This had never been produced by any other sealant. The overall performance of the material as a sealing agent in composite pipe with threaded connections was then evaluated.

The use of the polysulfide elastomeric as a sealing agent in composite pipe sections with threaded connections solves the above problems. In the uncured state, the material applies like a typical thread dope and when the connection is assembled displaces any potential thread leak paths. The material was proven through testing to be thread leak proof now extending the service life of the connection to that of the pipe. It requires no compression to make the seal, therefore, compression set does not pose a problem. The sealing contact area of the polysulfide connection is magnitudes higher than that of other elastomeric seals (example: 12.54 in^2 contact area in 2 3/8" 8RD connection.). The material also provides continuous permanent adhesion of elastomer material between the box and pin threads which cannot be washed away but may still allow the connection to be disassembled and reconnected. It also eliminates critical assembly torque requirements. It has been proven to produce seals to 10,000 psi hydrostatic from hand tight to power tight, uncured to cured, in composite connections.

Confirmation tests were then conducted to determine the ultimate performance of polysulfide elastomeric sealants in 8RD round threaded connections.

Polysulfide elastomeric sealant applied to 8RD cut/paste threads exhibited the best ultimate performance to date of any compounds evaluated. This polysulfide compound eliminates thread leaks as seen in tape and lube prepared connections without any mechanical performance losses that has been observed in epoxy adhesive joined connections. Application is easily made with a spatula.

The following polysulfide elastomerics were evaluated:

Table 1 - Types Polysulfide Elastomerics

Compound	Pot Life*	Tack Free Time*	Cure to 35 Shore A*
3205	20 min.	2 hrs.	12 hrs.
3204B 1/2	30 min.	8 hrs.	30 hrs.
3204B 2	120 min.	24 hrs.	72 hrs.

Table 2 - Typical Performance Properties of Polysulfide Elastomerics

Hardness	50 Shore A	14 days
Tensile	300 psi	14 days
Elongation	350 %	14 days
Peel Strength**	40 lbf/in	14 days in JP4
Peel Strength**	40 lbf/in	14 days in Brine
Thixotropic Paste When Mixed:		1,200,000 Centipoises
Maximum Service Temperature:		250 Degrees F.

*At 77 Degrees F, 50% Humidity.
**On Aluminum.

Table 3 - Chemical Resistance of Polysulfide Elastomerics

JP4	H O	Petroleum
Lubricants	Weather	Acetone
Oils	MEK	
	Ethers	

One 2010(*) connection of each elastomeric sealant from table 1 was made. The connection was brush cleaned with 1,1,1 trichoroethylene. The male was a 2010 nipple with paste threads and the coupling was a cut thread 2510(**). Make torques were 225 lb.ft. Cures were accelerated in the environmental chamber. One 3204B-2 elastomeric sealant was made in the same type of 2010 connection and evaluated for sealing capability while still uncured.

* 2010 is a 2,000 psi rated component

** 2510 is a 2,500 psi rated component

Results

Table 4 - Burst Pressures Polysulfide Connections

Connection	Sealant Type	Burst Pressure	Failure Type
2010 T&C	3205 Cured	9,222	Pin Thread Shear
2010 T&C	3204B 1/2 Cured	9,272	None
2010 T&C	3204B 2 Cured	10,000	None
2010 T&C	3204B 2 Wet	9,000	None

Table 5 - Short Term Cyclic Performance of

3204B 1/2 Polysulfide Connection

Connection	Cyclic Pressure	#	Cycles Failures
2010 T&C	8000+	10	None

These connections disassembled at approximately two times assembly torque without thread damage.

The polysulfide elastomeric sealants provided the best hydrostatic performance of any sealing system evaluated, tape with thread dope, anaerobics sealants, epoxies, flexibilized epoxies, etc.

The 3204B 1/2 compound is available from:
Chem Seal
11120 Sherman Way
Sun Valley, CA 91352
#818/982-1655

The Chem Seal company literature describes this compound as an aircraft fuel tank sealant. It further provides:

> CS 3204 is a fuel resistant sealant for use on integral fuel tanks and pressurized cabins as well as other areas subject to contact with aircraft fuels, lubricants, oils, water and/or weathering.
>
> CS 3204 is a two-part polysulfide based compound which cures at room temperature to a flexible, resilient rubber with excellent adhesion to aluminum, magnesium, titanium, steel, and numerous other materials. CS 3204 is designed to withstand the attack of sulphur compounds that are present in jet fuels. When mixed, CS 3204 Class A is a self-leveling liquid qualified to meet the MIL-S-8802E Type II Specification.
>
> TYPICAL PROPERTIES

Color: Base Compound, Part A   Off-white
Curing Agent, Part B   Black
Mixed   Gray
Mixing Ratio (by weight) Pts A:B   100:10
(by volume)   100:8.3
Non-Volatile Content   86%
Viscosity - Base Compound
(Brookfield RVF-Spindle #6 @ 10 rpm)   250 poises
Viscosity - Curing Agent
(Brookfield RVF-Spindle #7 @ 10 rpm)   1,000 poises
Ultimate hardness, Shore A   50

The composition of the sealant, in percent by weight, is 11% toulene (solvent) (200 ppm); 51% polysulfide polymer (vehicle); 3% titanium dioxide (pigment); 28% calcium carbonate (additives); and 7% manganese dioxide (catalyst).

Further testing of the 3205 B 1/2 polysulfide elastomeric sealant followed to determine if it could provide a reliable user friendly joint. In all phases of performance, the 3205 B 1/2 outperformed the standard joint prep of teflon tape and 2416 thread lubrication. In ultimate bursts (rapid pressurization of connection until leakage is observed), safety factors of 4.0 to 4.6 against failure were produced in 2010 T&C product independent of the make torque. In cyclics, nearly a two-fold increase in cyclic burst (pulsation of pressure ever two and one half seconds to connection. Determines endurance life of the connection) performance was obtained with the B 1/2. Disassembly torques were 1.5 to 2.0 times the assembly torques without thread damage. Threads were easily cleaned with a steel wire brush for remake.

<u>Background</u>

<u>Table 1 - Properties of B 1/2 Polysulfide Elastomeric</u>

Cure: 30 min. - pot life*, 2 hr. - tack-free*, 12 hr. - 35 Shore A*
Hardness: 50 Shore A in 14 days
Tensile: 300 psi in 14 days
Elongation: 350% in 14 days
Peel Strength**: 40 lbf/in. 14 days in JP4
Peel Strength**: 40 lbf/in. 14 days in Brine
Mix Viscosity: 1,200,000 Centipoise Thixotrophic
Maximum Service Temp: 250 Deg. F
Two Part Compound: 1 part Hardener: 10 parts Base
Color: Hardener-Black, Base-Cream, Mixture-Dark Grey
Chemical Resistance: JP4, Brine, MEK, Petroleum Oils, Lubricants, H20
*@ 77 Deg. F., 50% Humidity
** On Aluminum

<u>Testing and Evaluation of Polysulfide Sealed Connections</u>

1. 1.5 Times Rated Pressure by 24 Hour Hydrostatic Pressure Test

Four connections of 2" 2010 T&C composed of a cut thread 2510 coupling and a 2010 paste thread male nipple were evaluated for sealing capability with the B 1/2 over a extended period of time. The B 1/2 was applied to 1,1,1 tricholorethane cleaned pin and bell with a brush. The connection was assembled with 250 ft.lbf. of torque and immediately subjected to 3000+ psig hydrostatic pressure at room temperature while the B 1/2 was uncured. Results follow:

Candidate	Pressure	Time Under Test	Depressurization
#1	3000+	24 hrs.	No
#2	3000+	24 hrs.	No
#3	3000+	24 hrs.	No
#4	3000+	72 hrs.	No

2. Ultimate Bursts Comparison of Tape/Dope Connection vs. Polysulfide Sealed Connections

Multiple connections of 2: 2010 product with 8RD threads were connected and sealed with tape and dope (T&D) for controls. Addition connections of the same product was sealed with polysulfide elastomer (poly). Burst tests were then conducted. Performance was then compared. Note polysulfide was allowed to cure before testing.

Candidate	Seal	Ultimate (psig)	Failure Type
#1	T&D	8130	Thread Shear @ Steel Cap
#2	T&D	8716	Yes
#3	T&D	8638	Yes
#4	T&D	8142	Yes
#5	T&D	7998	Yes
#6	T&D	8768	Yes
#7	T&D	8254	Yes
#8	Poly	9058	No
#9	Poly	8338	No
#10	Poly	9272	No
#11	Poly	8494	No
#12	Poly	8271	No
#13	Poly	8366	No
#14	Poly	8246	No
#15	Poly	8494	No
#16	Poly	8364	No
#17	Poly	8262	No
#18	Poly	8364	No
#19	Poly	8260	No
#20	Poly	8424	No
#21	Poly	9286	No
#22	Poly	9230	No
#23	Poly	9700	No
#24	Poly	9540	No
#25	Poly	9200	No
#26	Poly	10000	No

Average Burst Pressure With Thread Leak Failures Tape/Dope Sealed Connection = 8378 psi

Average Burst Pressure without Thread Leak Failures Polysulfide Sealed Connection = 8800 psi

3. Uncured Ultimate Burst Test Polysulfide Sealant*

Four connections of 2" 2010 T&C with cut to paste threads were assembled with 250 ft.lbf. torque and polysulfide as the sealant. Ultimates were performed immediately after assembly while the elastomeric was still uncured. Results follow:

Candidate	Ultimate (Psig)	Failure Type
#1	> 8200	None
#2	> 8200	None
#3	> 8200	None
#4	> 8200	None

*Testing terminated @ 8200 psig to prevent plumbing failures.

4. Hand Tight Ultimate Burst Test*

Six connections of 2" 2010 T&C with cut to paste threads were assembled hand tight (1/4 turn past snug with #5 wrench) with polysulfide elastomeric as the sealant. Ultimates Burst were then performed:

Candidate	Cure	Ultimate Burst (Psig)	Failure Type
#1	Cure	8364	None
#2	Wet*	8504	None
#3	Wet	8342	None
#4	Wet	8460	None
#5	Wet	8502	None
#6	Wet	8258	Thread Leak

*Testing terminated @ 8200 psig to prevent plumbing failures.

5. Hand Tight Ultimate Burst Test Cut to Cut Threads Polysulfide Sealed

Five connections of 2" 2010 T&C with cut to cut threads were made-up hand tight (1/4 turn past snug with #5 wrench) with polysulfide elastomeric as the sealant. Ultimates Burst were then performed:

Candidate	Cure	Ultimate Burst Psig)	Failure Type
#1	Wet	7938	Thread Leak
#2	Wet	8360	None
#3	Wet	8620	None
#4	Wet	8250	None
#5	Wet	8312	None

6. Ambient Cyclic Test

T&C tape and dope (T&D) controls were cycled heads up against connections sealed with polysulfide. All connections were 2" 2010 T&C with cut to paste threads made with 250 ft.lbf torque. Cure was 24 hrs. at 150 degrees F. Note T&D = tape and dope.

*Wet polysulfide in uncrosslinked state.

Candidate	Cyclic Pressure	# Cycles to Failure	Failure Type
#1 T&D	2500	101,000	Thread Leak
#2 T&D	2500	103,117	Thread Leak
#1 B 1/2***	2500	198,976	None
#2 B 1/2	2500	198,976	None
#3 T&D	2750	112,960	Thread Leak
#4 T&D	2750	112,960	Thread Leak
#3 B 1/2	2750	208,731	*
#4 B 1/2	2750	208,731	**
#5 T&D	2000	810,000	No failure to date
#6 T&D	2000	810,000	No failure to date
#5 B 1/2	2000	810,000	No failure to date
#6 B 1/2	2000	810,000	No failure to date

*No thread leak to date, coupling weep @ 113,900.

**No thread leak to date, pipe body spray @ 114,476.

***Polysulfide elastomeric

7. Brine Solution Exposure Test

A 7.12g oven cured sample of B 1/2 elastomeric was exposed to a 210 degree F. 10% solution of NaCl. Both sample weight and durameter were monitored over a 22 day period. Neg. 1

Conclusions

1. The polysulfide elastomeric maintains a reliable joint while under cure during a typical hydrostatic field test of 1.5 x rating for 24 hours. Cure is complete in 24 hours at mild temperatures.

2. The polysulfide elastomeric produces ultimates 4.0 to 4.5 times rated pressure in 2010 T&C product independent of connection torque or cure. The typical B 1/2 ultimate burst exceeds the standard prep of tape and dope ultimate burst by 1000+ psi.

3. The polysulfide elastomeric provides a reliable connection in both cut to paste and cut to cut connection.

4. The polysulfide elastomer produces a connection with nearly a two-fold increase in cyclic endurance than the standard prep of tape and dope. As seen to date, the connection endurance has now exceeded the pipe and coupling endurance.

5. No adverse effects in mechanical properties occur when the polysulfide elastomer is exposed to brine solutions.

Various of the other features of the invention are apparent from the following claims.

CLAIMS

1. A method of joining non-ferrous pipe comprising:

a male threaded section, and

a female threaded section, the male and female pipe sections being intended to be repeatedly joined and disconnected, said method comprising the steps of:

applying a cold curable elastomeric compound with a durameter range of 30 to 60 Shore A to at least one of the male threaded section and the female threaded section, and then

threading the male section into the female section before said cold curable compound crosslinks so that an uncompressed elastomeric seal forms between the male and female pipe sections.

2. A method in accordance with Claim 1 wherein said elastomeric compound is an adhesive.

3. A method in accordance with Claim 1 wherein said elastomeric compound is has a low shear strength.

4. A method in accordance with Claim 1 wherein said elastomeric compound is applied to substantially all of the threads of the one of the male threaded section and the female threaded section.

5. A method in accordance with Claim 1 wherein said male and female pipe sections are made from resin impregnated fiber material.

6. Non-ferrous pipe comprising:

a male threaded section,

a female threaded section, said male and female pipe sections being intended to be repeatedly joined and disconnected, and

a cold curable elastomeric compound with a durameter range of 30 to 60 Shore A between said male threaded section and said female threaded section, said compound having cured after said male section was threaded into said female section and before said cold curable compound crosslinked so that an uncompressed elastomeric seal formed between said male and female pipe sections.

7. A method of joining non-ferrous pipe comprising:

a male threaded section, and

a female threaded section, the male and female pipe sections being intended to be repeatedly joined and disconnected, said method comprising the steps of:

applying a cold curable elastomeric adhesive compound with a low shear strength and with a durameter range of 30 to 60 Shore A to at least one of the male threaded section and the female threaded section, and then

threading the male section into the female section before said cold curable compound crosslinks so that an uncompressed elastomeric seal forms between the male and female pipe sections.

8. A method in accordance with Claim 7 wherein said elastomeric compound is applied to substantially all of the threads of the one of the male threaded section and the female threaded section.

9. A method in accordance with Claim 7 wherein said male and female pipe sections are made from resin impregnated fiber material.

10. A method of joining non-ferrous pipe comprising:

a male threaded section, and

a female threaded section, the male and female pipe sections being intended to be repeatedly joined and disconnected, said method comprising the steps of:

applying a cold curable polysulfide elastomeric compound with a durameter range of 30 to 60 Shore A to at least one of the male threaded section and the female threaded section, and then

threading the male section into the female section before said cold curable compound sets so that an uncompressed elastomeric seal forms between the male and female pipe sections.

11. A method in accordance with Claim 10 wherein said elastomeric compound is applied to substantially all of the threads of the one of the male threaded section and the female threaded section.

12. A method in accordance with Claim 10 wherein said male and female pipe sections are made from resin impregnated fiber material.

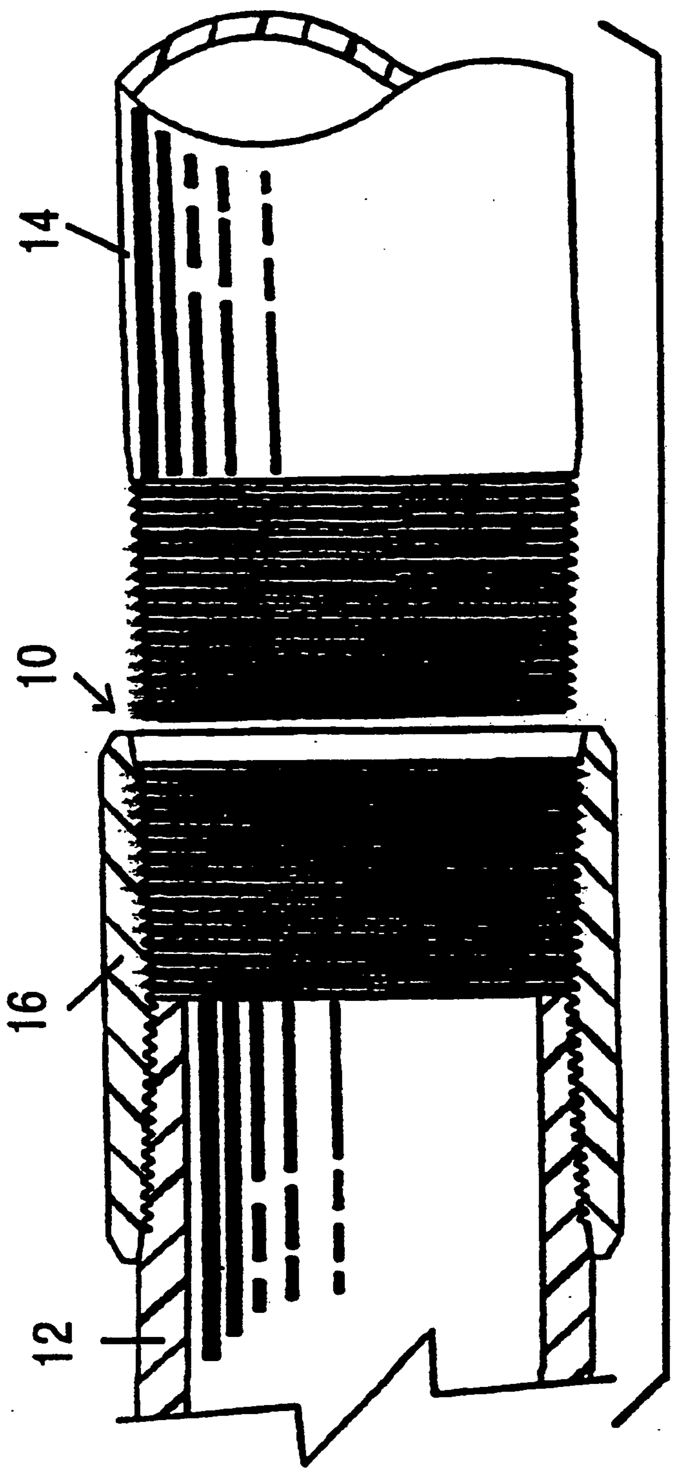

Fig. 1

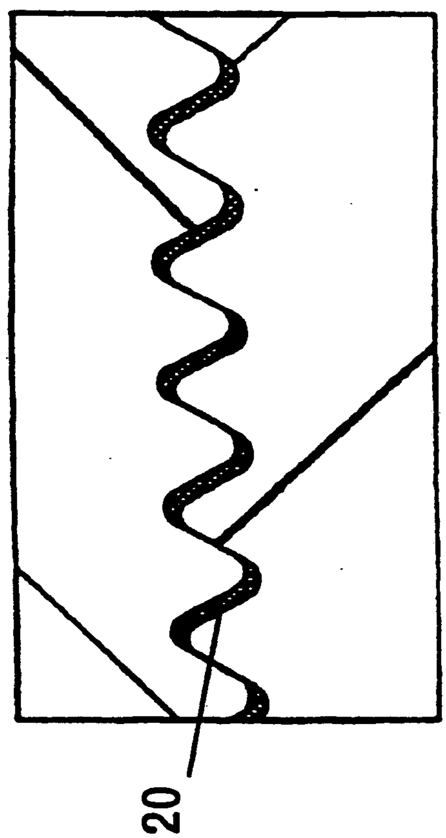

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/US91/03597

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC
IPC(5): B29C 65/48; F16L 15/00; F16L 47/02
US CL : 285/355,423,915,919

II. FIELDS SEARCHED

Minimum Documentation Searched

Classification System	Classification Symbols
US	156/158,294 285/333,334,355,390,423,915,919

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	US,A 4,200,480 (WOLINSKI et al) 29 April 1980 col. 3 lines 55-57, col. 4 lines 34-68	1-12
A	US,A 4,023,834 (EWING et al) 17 May 1988 See col. 12 lines 23-26	1,6,7,10
A	US,A 3,784,239 (CARTER et al) 09 January 1974 See Figure 6	1,5-7,9,10 12
Y	US,A 3,572,392 (McLARTY) 23 March 1971 See col. 4 lines 58-58	1-12
A	US,A 3,540,757 (NEHER) 17 November 1970 See col. 1 lines 39-46	1-12
Y	US,A 3,407,101 (LOCKSHAW) 22 October 1968 See col 1 lines 20-35, col. 5 lines 16-17 col 6 lines 5-15	1-12
A	US,A 3,366,504 (HULTERSTRUM) 30 January 1968 See figure	1-12
Y	US,A 3,101,207 PAVEL et al) 20 August 1963 See Fig. 1, col. 3 line 52, col. 4 lines 40,41	1-12
A	US,A 2,876,154 (USAB) 03 March 1959 See Fig. 2	1,6,7,10

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14 AUGUST 1991	20 SEP 1991
International Searching Authority	Signature of Authorized Officer
ISA/US	Michael W. Ball

Form PCT/ISA/210 (second sheet) (May 1986)

OIPE JC174
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
A	WO,A 90/00236 (ELLSWORTH) 11 January 1990 See Fig.s 1,2	1-12
A	DE,A 2,340,177 (WESCH) 31 October 1973 See Fig. 1-6	1-12
Y	Encyclopedia of Polymer Science and Engineering vol. 13 pg. 186-196, vol 15 pg 131-138, 1989 See vol 13 page 186,188,192, vol 15 page 132,133,136	1-12

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